A Detailed Assessment of Mining Land Transformation Factors in Australia

Methodology

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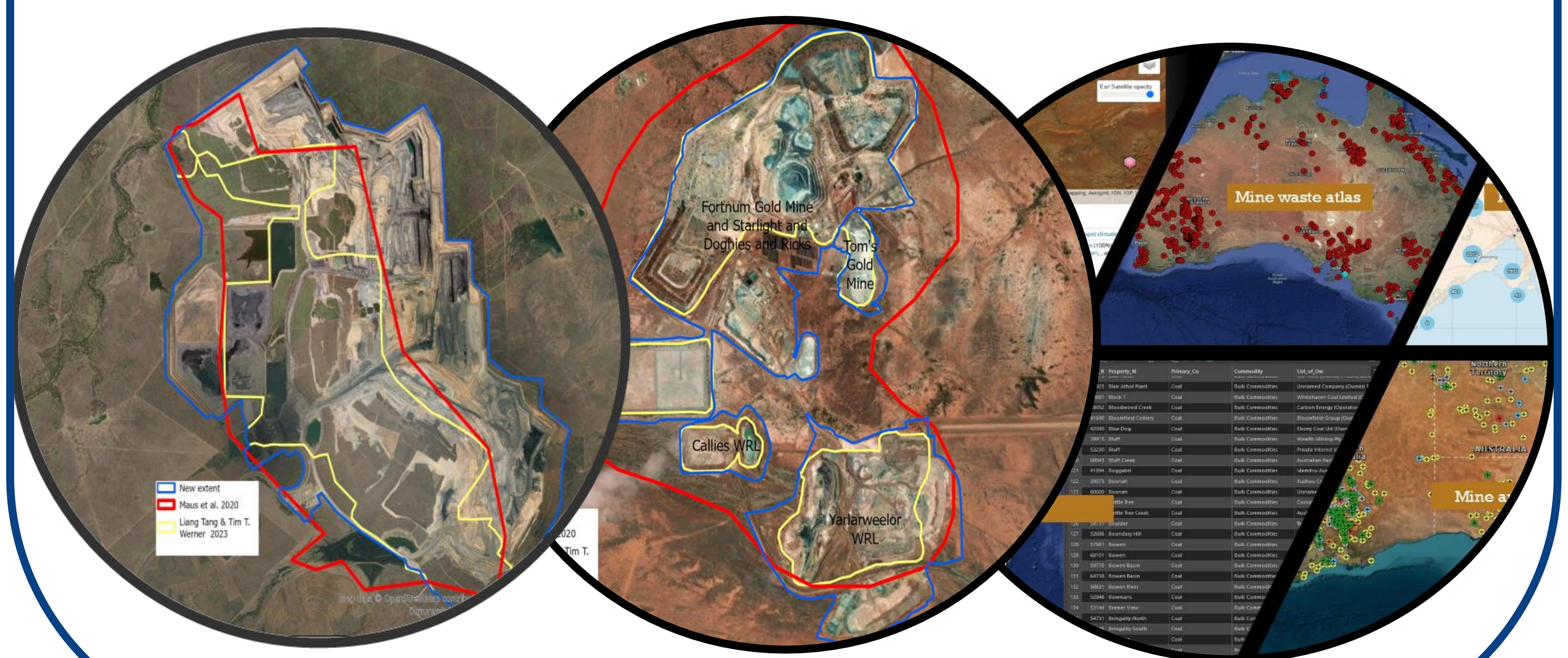
Introduction

The global shift toward green energy is driving a dramatic increase in demand for critical minerals such as Lithium, cobalt, nickel, and copper, which are essential for renewable energy technologies and electric vehicles. This surge in demand fundamentally alters mineral and energy resource flows, with projections indicating a 200–900% increase in mineral production for the electricity sector and a 350–700% increase for the transport. Understanding the spatial and environmental footprint of mining is crucial, as expanding mining areas can have significant social, environmental, and cultural impacts. These include increased mine waste, land transformation, and conflicts with local communities, particularly in regions with sensitive ecosystems or Indigenous territories.[3-5] Australia is a major player in the global supply of critical minerals,[6] positioning itself as a key supplier for the green energy transition. Its vast mineral resources and established mining sector make it central to meeting rising global demand. It also places it at the forefront of debates about sustainable mining practices and the need for robust regulatory frameworks.[7,8]



Goals

1. Creating the most comprehensive database for mine sites in Australia
2. Linking mine polygons with site-specific data.
3. Assessing the Land Transformation Factors (LTFs)

Methodology

Data collection was conducted through a comprehensive review of diverse online sources, including organisational websites, industry reports, academic papers, and publicly available databases released by reputable institutions. Building a mine dataset is hindered by a lack of accurate and accessible mine footprint data. There is no unified database linking mine footprints to production. The boundaries of all mine sites, regardless of their operational status, were analysed, and the latest land footprint, based on the most recent satellite imagery, was redrawn. Below are the names of the datasets used in this stage.

Dataset/Article	Author/s & Date of Release	Data type (Point, Polygon)	Alignment with this research (Spatial accuracy, coverage, completeness and validity)	Coverage
Australian Mines Atlas	Geoscience Australia, 2018		★★★	Australia
A Geospatial Database for Effective Mine Rehabilitation in Australia	Werner et al., 2020		★★★	Australia
Global-scale remote sensing of mine areas and analysis of factors explaining their extent	Werner et al.,2020		★★☆	Global - Detailed Land Use and Land Cover Maps of 295 Mines
A global-scale spatial assessment and geodatabase of mine area	Tang et al., 2021		★★☆	24,605 mine area,117 countries
A global-scale data set of mining areas	Maus et al., 2022		★☆☆	Global - 44,929 mine area
Global mining footprint mapped from high-resolution satellite imagery	Liang Tang & Tim T. Werner., 2023		★★★	Global - 74,548 mine area
mindat.org	Hudson Institute of Mineralogy (continuously updated by the community)		★★☆	Global
S&P Capital IQ Pro (formerly S&P Global Market Intelligence) database	Capital market company(updated annually)		★☆☆	Global

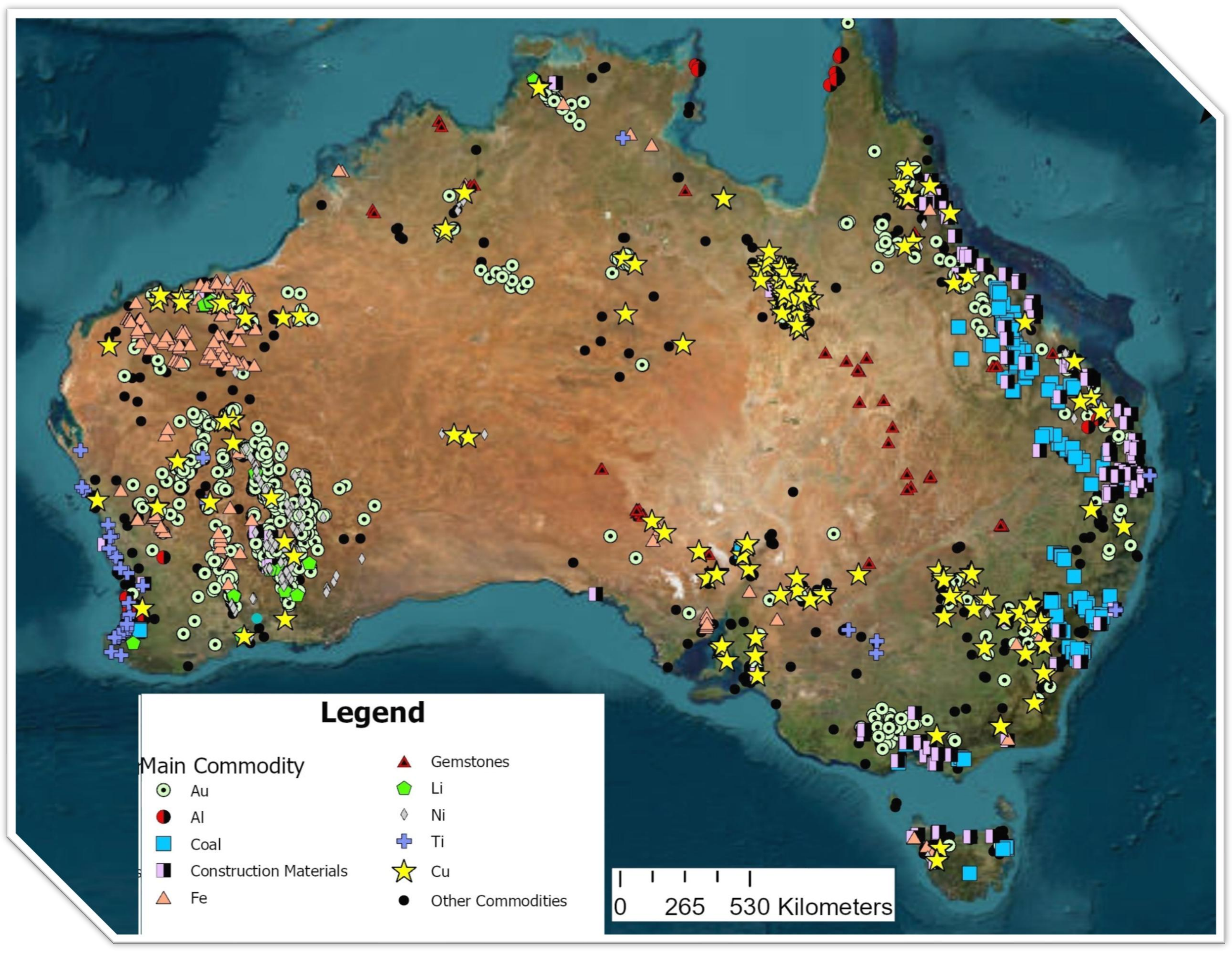
To calculate the Land Transformation Factor (LTF) values, the dataset published by Gavin Mudd (2023)[9] was integrated after verifying and assigning the correct site names and their corresponding areas. This dataset provides detailed information on mine sites across Australia from 1979 to 2021. The LTF expresses the relationship between the total occupied land area (Am,t) and the cumulative production of the material (P) over the period [t_0, t].

$$LTF_{m,t} = \frac{A_{m,t}}{\sum_{t_0}^{t} P_t}$$

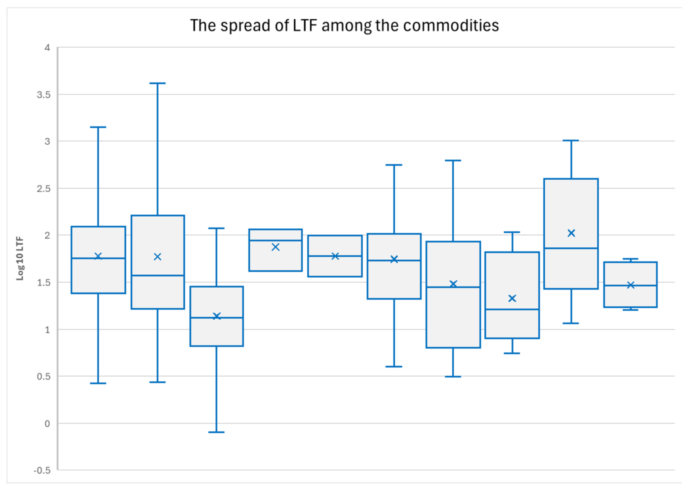
Results & Discussion

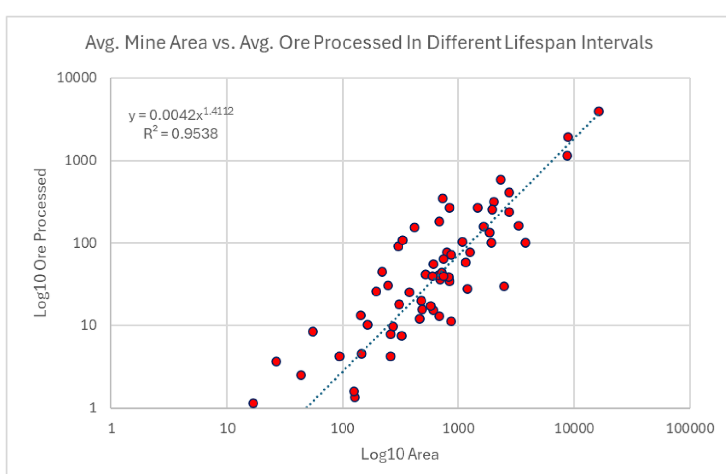
Snapshot of the attribute table for Brockman 4

State (2021)	Western Australia
Project / Field / Ore Deposit	Brockman 4 Area / Rio Tinto
WebSites	https://www.mindat.org/loc-273361.html
Name	Brockman 4
Status_Mud	Op
Status(GeoScience Australia 2024)	Active (Operating)
LTF(ha\Mt) NEW	4.191983152
OreProcessed Mt	3922.34592
WasteRock(Mt)	ND
IronOre-Conc-Amount(Mt)	3,922.3
Other Names Or Facilities	Brockman 4 - Pit 2 Final; Brockman 4 Desposit R; Brockman 4 Pit 3 West; Brockman 4 Deposit Q; Brockman 4 Pit 3 East;
Area (ha)	4166.2693
Main Commodity/Element	Fe
Other Commodities/Minerals	
Operating Period	1966-2025
List_of_Ow	Rio Tinto (Owner) 100%
IronOre-Conc-Fe(%)	65.4E
MetMinExt-FeOre(Mt)	3,922.3
Long	117.21
Lat	-22.60
Uncertaint	U2, U6
Image_Date	19/11/2023



The dataset comprises over 100 data fields and contains more than 50,000 data entries associated with mine sites. It has more than 2800 polygons with a total area of 847,584 hectares. An initial analysis of the results reveals a strong positive correlation between average production and average mine area. This relationship appears consistent across all mineral types and extraction methods, suggesting a strong link between production and spatial footprint. It is expected that further classification and the inclusion of additional mine sites will strengthen this correlation. The relationship between mine lifespan and Land Transformation Footprint (LTF), as illustrated, it exhibits a clear downward trend. This observation supports the initial hypothesis that, despite increased mineral output, the rate of land transformation per unit of production is declining. This trend may be driven by a range of factors that warrant further investigation in subsequent stages of this study.



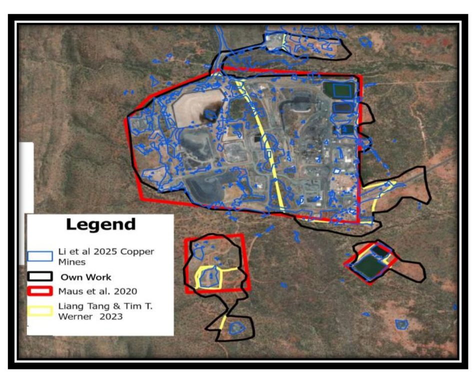


Dataset	Mining area (Sq km)	No. Polygons
Maus et al. (2022)	6471.1824	1797
Tang and Werner (2023)	5319.6957	4073
Own work	8475.8488	2808

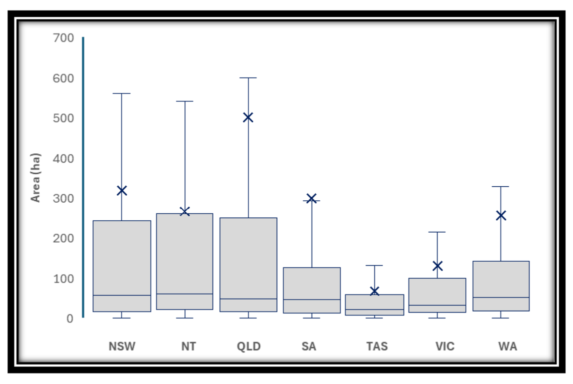
Top 5 Commodities by Sum Area

Primary Commodity	No. Polygons	Sum area of active and inactive mine sites (ha)
Coal	197	266,394
Fe	161	165,184
Au	1178	139,936
Al	27	70,289
Ni	143	36,803

A comparison between existing datasets for mining footprint



Average area of mines in Australia



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Acknowledgments

This poster is part of my PhD research, conducted under the supervision of Dr. Tim Werner and Prof. David Phillips, and supported by a Melbourne Research Scholarship from the University of Melbourne.

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